Field Observations of Transient Ground Water Mounds Produced by Artificial Recharge into an Unconfined Aquifer

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FIELD OBSERVATIONS OF TRANSIENT GROUND WATER MOUNDS PRODUCED BY ARTIFICIAL RECHARGE INTO AN UNCONFINED AQUIFER

By W. C. Bianchi and E. E. Haskell, Jr.[1]

INTRODUCTION

The accurate definition of storage changes in basin subunits and in proximity to individual recharge areas can mean a refined and expensive observation network of wells, and frequent monitoring. This occurs when a ground water basin is artificially recharged at isolated points or if the basin is not under control of a single water service unit or district. Therefore, to describe basin ground water hydrology, the engineer first uses what little direct observational data are available as a base from which to apply idealized groundwater flow theories to approximate storage distributions with time. Because of the great lack of observational ground water data in most ground water basins, this may be the only way engineers have of predicting the effects of ground water withdrawals and recharge over a long term.

The primary objective of this report is to present data on the three-dimensional shape of ground water mounds produced by artificial recharge through water spreading. Such data, along with the boundary conditions and aquifer constants, will be used to test advances in theoretical methods of description of this phenomenon. The use of this data is illustrated by comparisons drawn between the theoretical derivations of Glover[2] and data gathered at two separate field recharge sites. These sites were selected to give us as close a control on water table elevation observations, stratigraphic definition, and aquifer description as was practical. The extensive tabular data are meant to provide other theorists with a data bank on which to test their theories as they are developed.

In engineering application, these ground water mound equations are of value in--

1. Predicting elapsed time before water logging occurs along leaking canal sections.
2. Predicting amounts of ground water storage associated with natural and artificial recharge sites.
3. Predicting responses of the water table at individual locations for optimizing operational recharge.
4. Predicting the time required for a recharge-formed mound to decay to a given height.

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[1]Soil scientist and program analyst. Agricultural Research Service, 4816 East Shields Avenue, Fresno, Calif. 93726.

[2]Glover, R. E. Mathematical derivations pertaining to ground water recharge. U.S. Dept. Agr., Agr. Res. Serv., 81 pp. Ft. Collins, Colo. 1961. [Mimeographed.]

5. Analyzing these theoretical relations in comparison with actual field observations and in determining how they are influenced by the various parameters that affect them.

The computer programs (*3*)[3] used in the evaluation of Glover's theory, were written in FORTRAN IV for use with an IBM-1130 computer. These programs are available on request from the senior author.

Generally, the engineer is interested in estimating the position of the water table at any given time and distance from the center of a recharge area during and after recharge. The general nature of the mathematical solutions offered by the heat flow analogy (*6,14*) are excellent for this purpose. However, certain concessions must be made concerning the nature of ground water flow relative to ideal heat flow. These concessions, called the Dupuit-Forschheimer (D-F) assumptions (*7,9*), can be stated as follows:

1. Flow within the ground water body occurs along horizontal flow lines whose velocity is independent of depth.
2. The velocity along these horizontal streamlines is proportional to the slope of the free water surface.

Several workers--Baumann (*1*), Glover,[4] Bouwer (*4,5*), Bittinger and Trelease (*3*), Hantush (*11*), and Marmion (*16*)--have either applied or discussed their assumptions and the resulting mathematical solutions to the analysis of transient ground water mounds.

COMPARISON OF FIELD OBSERVATIONAL DATA WITH THEORETICAL EVALUATIONS

The best test of theories designed to describe ground water flow is to compare actual full scale field recharge water table responses with those predicted in theory by using constants experimentally evaluated at the site. This allows all the practical problems of errors in boundary value, definition, aquifer constant evaluation, and data acquisition to enter and be weighed in the comparison.

For the most part, the application of mathematical theory to the description of ground water mounds has evolved on assumptions which may bend nature into a form that can be handled by theory. These assumptions fall into three general categories: First, the mathematical relationship chosen to describe the flow pattern most likely to occur in the field; second, the mathematical description of the geometric boundaries in the flow system; and third, the "constants" describing the aquifer through which flow occurs and the distribution of recharge as it enters the water table. A great deal of time has been spent on debating flow assumptions, but because of material requirements necessary for controlled field experiments the importance of the last two carries only brief comment in the literature.

Geometric Description and Location of Experimental Recharge Ponds

Two-acre ponds were located in western Fresno County, Calif., on the gently sloping alluvial fans, deposited by streams from the Diablo range. The ponds were approximately 13 miles apart, pond No. 1 near Five Points and No. 2 near Cantua. The surface soil was classed as a Panoche clay loam. The ponds were square, with observation wells (3/8-inch pipe) jetted to below the water table along the perpendicular bisectors of the sides as shown in figures 1 and 2.

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[3]Italic numbers in parentheses refer to Literature Cited, p. 15.

[4]See footnote 2.

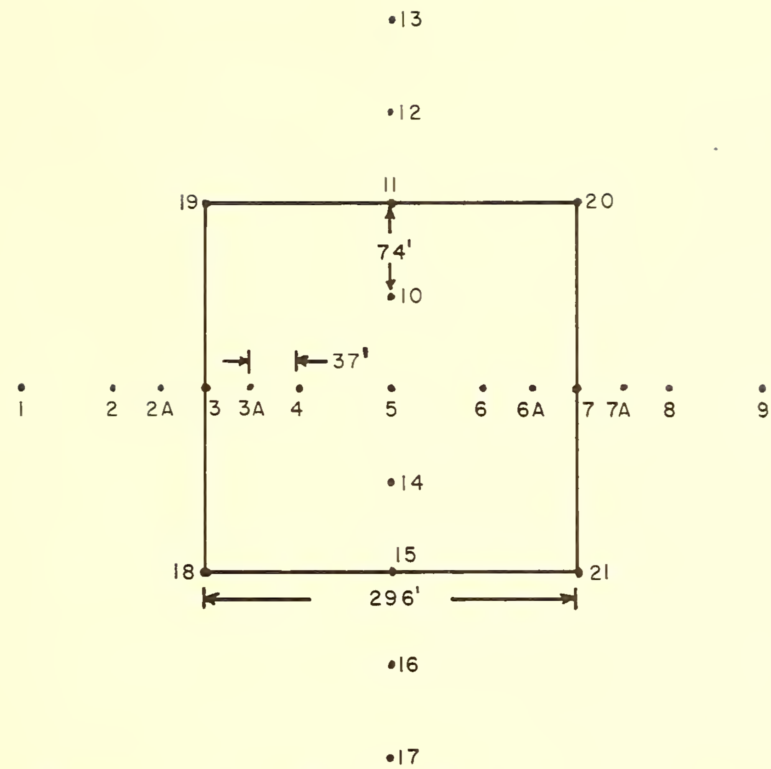

Figure 1.--Well numbering and geometric description for pond No. 1, Westside Field Station at Five Points.

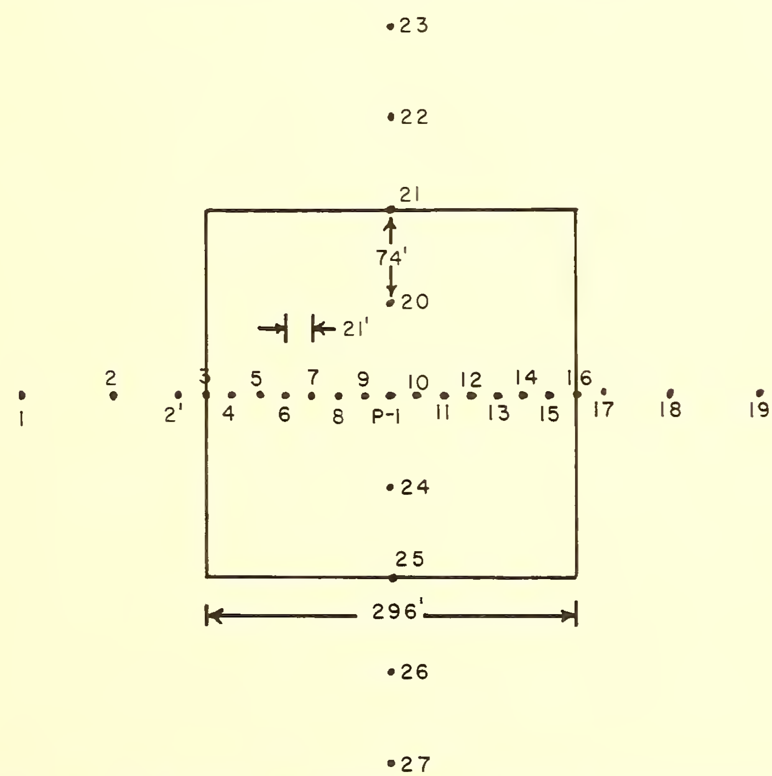

Figure 2.--Well numbering and geometric description for pond No. 2, near Cantua Creek.

Measurements of Water Table Position

The water table measurements were obtained with a chalked steel addtape to the nearest 0.01 foot. The measurements were taken over the entire traverse at a frequency dependent upon the expected rates of rise and fall of the mound. Appendix table 1 gives the data in the form of each well's rise above a reference head determined as an average of a number of readings taken prior to the start of spreading and corrected for atmospheric pressure changes (*2*), for pond No. 1 at the University of California Westside Field Station at Five Points. Appendix table 2 contains data from each well at pond No. 2, near Cantua Creek, 10 miles west of Five Points. In Appendix table 2 (pond No. 2) the wells designated with "A" (that is, 3A, 5A, . . .) refer to shallow wells that were added at locations 3, 5, . . . (fig. 2) after the neutron probe access tube P-1 showed that perching was occurring in the profile above the pre-existing water table.

Effect of Perching Upon Water Table Observations

A plot of the observed rise in head over the initial water table level for comparing deep and shallow wells is shown in figure 3. This plot includes observations during both the rise and fall of the mound. The ratio of head rise deep to head rise shallow is constant through the range. As seen in figure 4, this slope approached a value of 1.00 outside the pond boundaries and 1.50 within the pond. So the perching phenomenon was confined to the area beneath the pond where the direction of flow was closest to vertical. Drilling the central

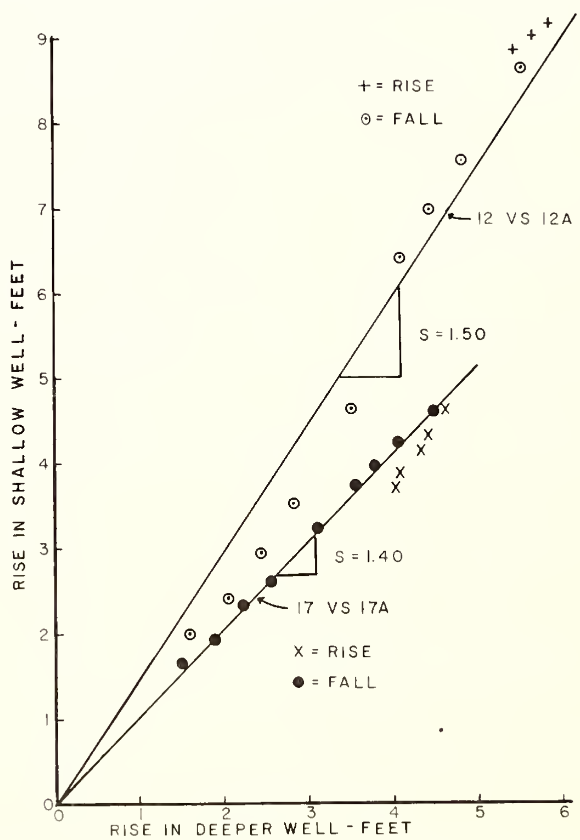

Figure 3.--Observed rise in the shallow well compared with that in the deep well for two sites.

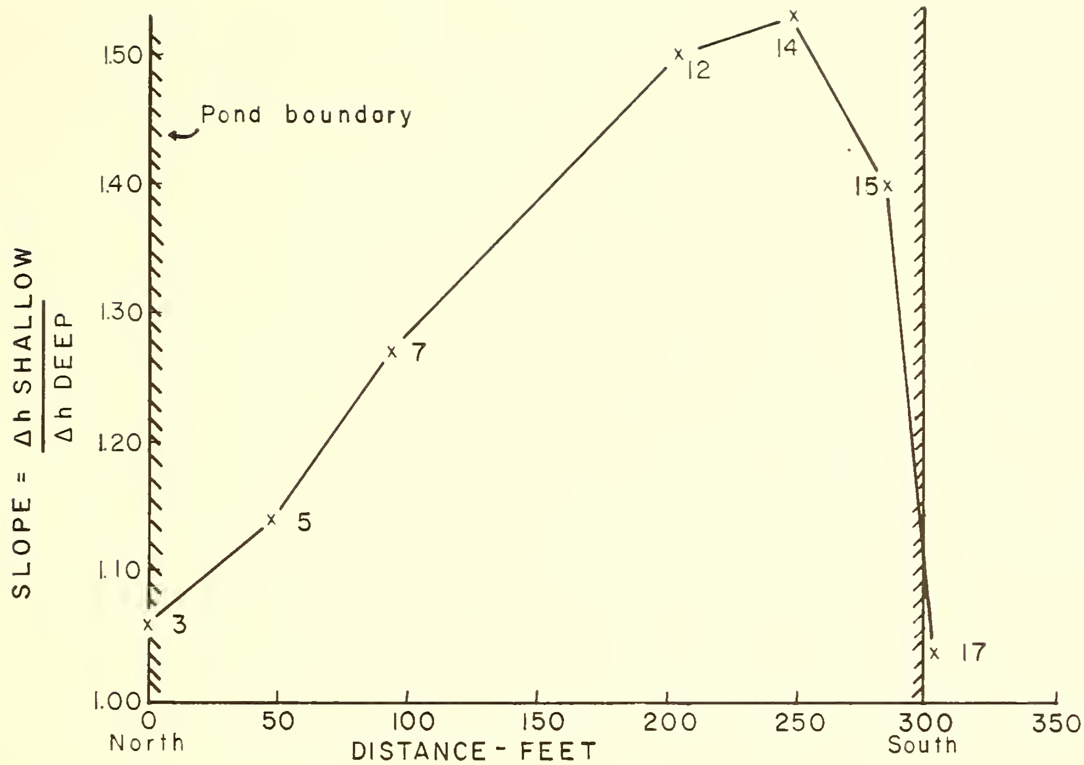

Figure 4.--Change in the slope of the head loss ratio (shallow over deep well) as a function of position beneath the pond.

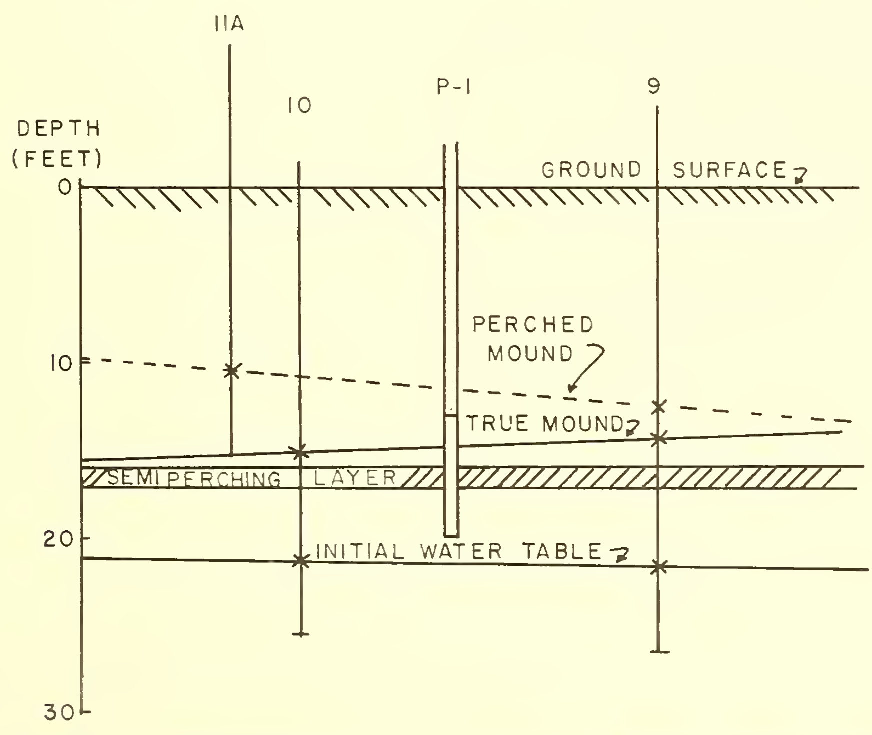

Figure 5.--Position of semiperching layer above the water table and the resulting effects on the observed well levels at pond No. 2.

well and other profile observations indicated that a layer of heavier textured material existed in the profile at the center of the pond between 17 and 18 feet below ground surface. This layer and the initial and maximum position of the mound are indicated relative to one another in figure 5. Apparently, the true ground water mound has a perched mound superimposed over it but only just beneath the plot. Had recharge continued, the real mound would, no doubt, have overridden it. For theoretical comparisons, the mound was considered to be that measured by the deeper wells, and the storage in the perched mound was considered to be just part of that present in the vadose zone.

Determination of Aquifer Properties

The saturated depth (*D*) was first estimated by determining if zones of high vertical head loss were present in the profile beneath the static water table. The water table was 25 feet below ground surface at pond No. 1 and 20 feet, at pond No. 2. Piezometers showed a true perching layer existing at an approximate depth below ground surface of 100 feet in both locations. Subsequent drilling and coring in the area of the ponds (*13*) revealed a depth of 100 feet (D = 75 feet) for pond No. 1 and 101 feet (D = 80 feet) for No. 2. However, at pond No. 1 the actual horizontal hydraulic restriction or impeding layer (see fig. 6) only became evident when development of the large central well was being carried out prior to the well test experiments. Because the vertical movement was practically nonexistent through the deeper layer, no head loss was measurable across the shallower 41-foot layer (D' = 16 feet) until significant vertical flow was caused by pumping the well.

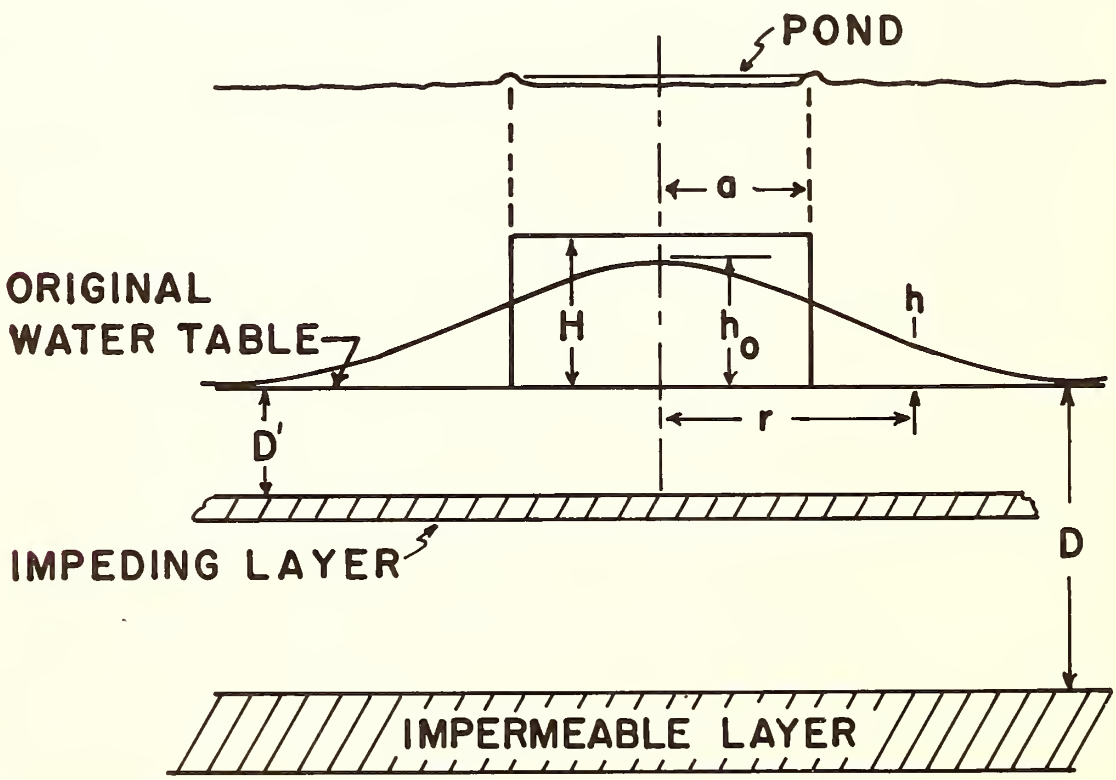

Figure 6.--Assumed and measured geometric values necessary for the theoretical description of the recharge mound.

The aquifer permeability (K) and fillable void (V) used in all evaluations were based on a single pumping test at each pond. The observation wells used to monitor the ground water were also used in this test. The pumped well was rotary drilled with mud to a diameter of 6 inches, cased, and gravel packed. Both were fully penetrating because a concrete plug was poured at a depth of 41 feet at pond No. 1.

Other Parameters

The recharge rate (i) was taken as the rate that water enters the surface of the pond. Theoretically, i is considered independent of time since start of operation and with the water entering the water table uniformly over the project plot area. For these ponds, this was not the case because the movement of air beneath the pond produced considerable curvature in the advancing wet front and measurable changes in vadose zone storage after recharge commenced (*2*).

The instant that recharge commenced ($t = 0$) was best estimated from the position of the wet front as determined by neutron probe measurements (*2*). The initial position of the water table was best determined from well observations prior to flooding, corrected for barometric fluctuations.

EXPERIMENTAL RESULTS

Rising Hydrograph at Center of Mound

Glover[5] treated theoretically the water table case of the rise of the center of the mound beneath both square and round spreading areas subject to continuous discharge and found that both geometric shapes provide nearly identical hydrographs. The circular case is described by his equation 16 as follows:

$$h_0 = Rt\left[1-e^{-U_1}+U_1\int_{U_1}^{\infty}\frac{e^{-U}}{U}dU\right] \tag{1}$$

where

$$U_1 = \frac{a^2}{4\alpha t} \tag{2}$$

$$R = \frac{i}{V} \text{ at } t\geq 0 \text{ from } 0\leq r\leq a \tag{3}$$

and

h_0 = rise in water table above initial static level
t = elapsed time after recharge starts
a = equivalent radius of the recharge area
i = uniform continuous recharge rate
$\alpha = KD/V$ = (the aquifer constant)

[5]See footnote 2.

in which

K = hydraulic conductivity or aquifer permeability
V = void ratio or fillable void
D = saturated thickness of aquifer

The integral in equation 1 is the exponential integral and has been evaluated by Jahnke (*15*).

Figure 7 shows the agreement of these data at the center of the mound with that observed during the test. If D = 75 feet is used in the theoretical evaluation of pond No. 1, a drastic deviation is apparent (fig. 7*A*). The rise evident in the observed data prior to recharge (t = 0) has been explained as the localized response at the observation wells to the air pressure beneath the wet front (*2*). The deviation from theory shortly after t = 0 can be attributed to two possible sources: the absence of instantaneous uniform recharge, $R = i/V$ in equation 3,and the absence of the theory's consideration of vertical flow. The latter would be most significant when the mound is most rapidly rising and small in lateral extent. The deviation as t gets larger, particularly for pond No. 2 (fig. 7*B*), could be due to the increase in D as the mound rises or the increase in V as most of the storage change shifts to outside of the projected pond boundaries, as suggested by Bouwer (*4*). The storage capacities beneath and outside of the projected pond area within the zone of rise of the water table were estimated by nuclear scattering methods as indicated in the fillable void values, 1 and 2 in table 1. While not directly comparative, the ratio of the difference in the two values to that found by the pump test gives an index of comparison between ponds. This ratio for pond No. 1 was 1.57 and No. 2, 5.36. As the hydrograph divergence is most apparent in pond No. 1, it would seem that the relatively large increase in D is the dominant influence rather than a shift in storage from beneath outside the projected pond boundaries. Both these changes, however, are undoubtedly responsible for quasi-equilibrium, which is apparent in both hydrographs for large t.

Lateral Spreading of the Mound

Glover[6] provides a solution for the rise of a ground water mound due to continuous recharge applied on a pond of width W and length L. His equation 87 is as follows:

$$h = R\int_0^t \left(\frac{1}{\sqrt{\pi}}\int_{U_1}^{U_2} e^{-U^2}\,dU\right)\left(\frac{1}{\sqrt{\pi}}\int_{U_3}^{U_4} e^{-U^2}\,dU\right)d\eta \qquad (4)$$

where

$$U_1 = \frac{\left(X - \frac{W}{2}\right)}{\sqrt{4\alpha(t-\eta)}}, \qquad U_2 = \frac{\left(X + \frac{W}{2}\right)}{\sqrt{4\alpha(t-\eta)}}$$

$$U_3 = \frac{\left(Y - \frac{L}{2}\right)}{\sqrt{4\alpha(t-\eta)}}, \qquad U_4 = \frac{\left(Y - \frac{L}{2}\right)}{\sqrt{4\alpha(t-\eta)}} \qquad (5)$$

[6]See footnote 2.

and

h = the rise in the water table at any point x, y from the center of the rectangle.

$Rd\eta$ = the incremental rise in the water table associated with the continuous application of water at rate i for the time interval $d\eta$.

For a square area ($W = L$), the two interior integrals reduce to twice the Probability Integral between 0 and U_2 and 0 and U_4 so they can be evaluated from existing tables (*17*). Thus, using Simpsons Rule, the time integral was evaluated for our measured boundary values (table 1) by computer techniques.[7] The theory was evaluated for x and y values as shown in Appendix table 3, and the observed data were averaged as shown. Mound contours were then plotted as shown in figure 8.

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[7]Bianchi, W. C., and Cotton, G. A. Computer programs for the transient shape of ground water mounds beneath artificial recharge areas. Fresno Field Sta. Ann. Rpt., 90 pp. 1967. [Mimeographed.]

Table 1.--*Physical constants, methods, and notation*

Constant	Notation	Description of Method	Evaluation Pond No. 1	Evaluation Pond No. 2
Plot width, ft	W[1]		295	295
Equivalent radius, ft	a	From plot area.	166.4	166.4
Saturated depth, ft	D	Well logs, electric logs, core sampling.	75	80
Impeding layer, ft		Well test.	16	---
Recharge rate, ft/day	i	Average intake over flooding period.	0.32	0.35
Fillable void	V	1. Total pore space minus volume moisture prior to passage of wet front; gamma ray and neutron probe techniques.	0.26	0.17
		2. Total pore space minus volume pressure after passage of wet front; gamma ray and neutron probe techniques.	0.12	0.052
		3. Well test data; Theis nonequilibrium method average from four lines of partially penetrating observation wells.	0.089	0.022
Hydraulic conductivity, ft/day	K	Well test data; Theis nonequilibrium method average from four lines of partially penetrating observation wells (*8*).	104	26

[1]Square.

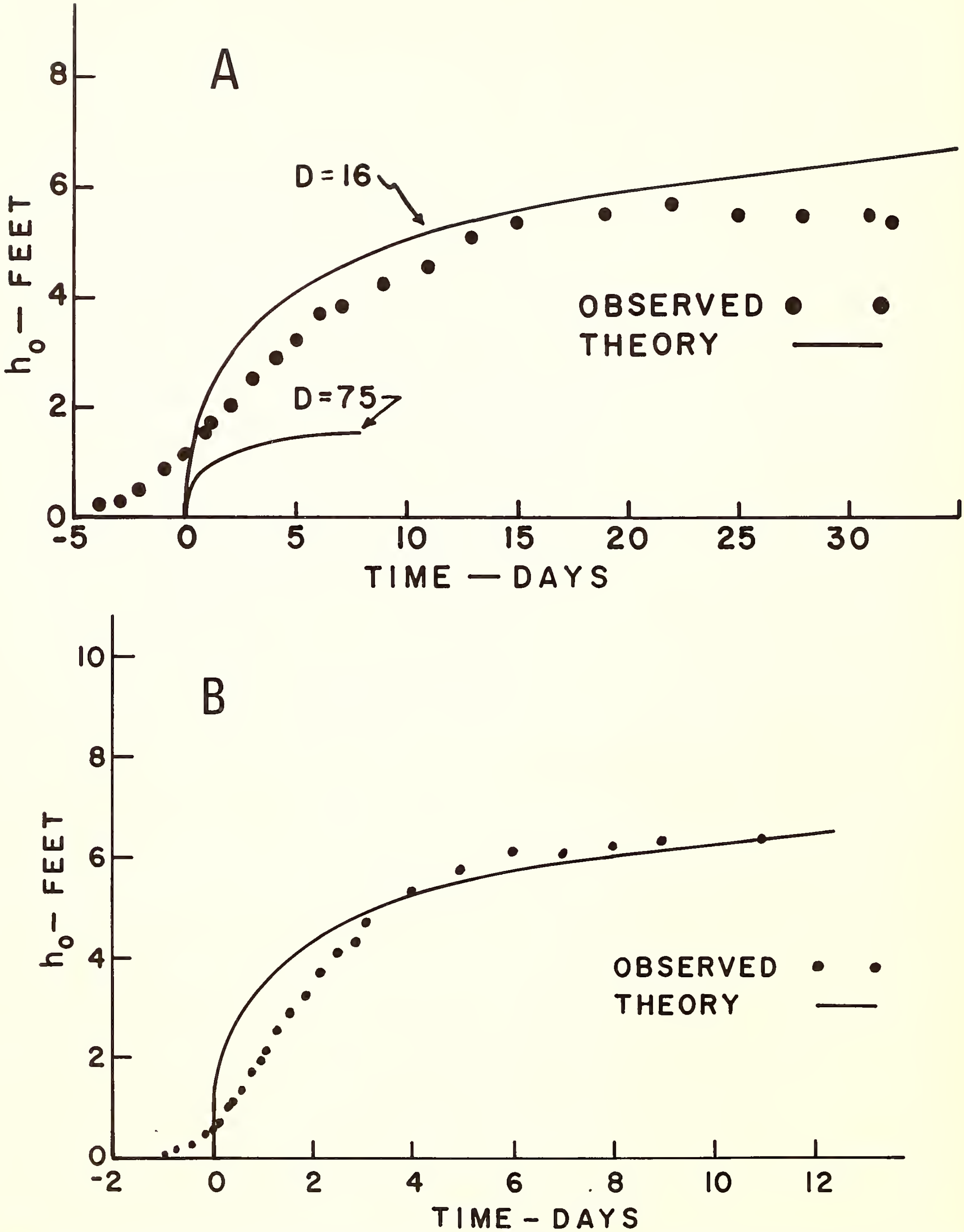

Figure 7.--Observed and theoretical rising hydrographs--*A*, at the center of pond No. 1, Westside field station at Five Points; *B*, at the center of pond No. 2, near Cantua Creek.

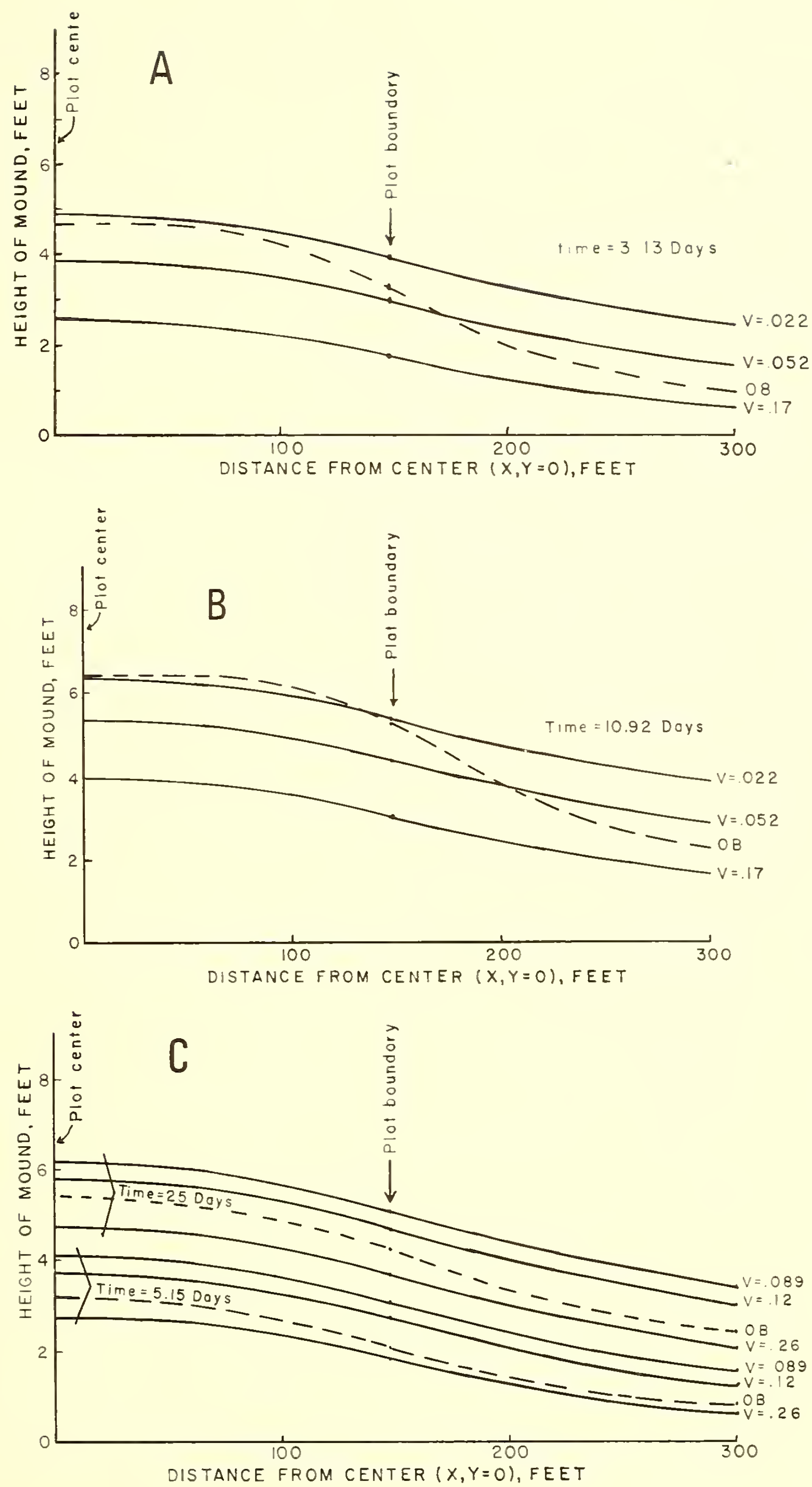

Figure 8.--Comparison of Rectangular Theory, observed, and void: *A*, at pond No. 2 after 3.13 days; *B*, at pond No. 2 after 10.92 days; and *C*, at pond No. 1 after 5.15 and 25 days.

The influence of the lateral shift in storage outside the plot boundaries is quite evident in the mound cross sections from pond No. 2 (fig. 8*A* and *B*). Under the pond, the observed mound (identified as *OB*) is closely approximated by the theory based on the minimum V obtained from the well test (see table 1). The cross sections approach the theoretical cross section outside the plot associated with the maximum estimated V. The same is evident, but to a much lesser extent, at pond No. 1 (fig. 8*C*) where the relative change in void is smaller, and the overriding effect of D is the main influence. In both comparisons, however, an estimate of the void outside the pond boundary is needed if an acceptable theoretical estimate of the ground water mound height is to be obtained.

Falling Hydrograph

A modificiation of equation 1 can be used to estimate the fall of the center of our observed ground water mound if we assume it to have a disk shape with idealized radius (a) and initial height (H). Equation 1 takes the form:

$$h_o = H\left(1-e^{-a^2/4\alpha t}\right) \tag{6}$$

We can assume that H equals the final observed height of the rise of the mound. From this value, we can approximate a from the total volume of water storage in the mound when spreading ceased, plus the water that drained from the vadose zone beneath the plot during the period of observed fall. This was accomplished as follows:

Let V_a' = the total volume of water metered on the 2-acre ponds (acre feet)
V_i' = volume of water in vadose zone at the beginning of spreading (acre feet)
V_r' = volume of water in vadose zone at end of spreading (acre feet)[8]
V_f' = volume of water in vadose zone at the end of observed fall (acre feet)
V' = effective mound volume (acre feet)

then the total volume of the mound plus that volume of water draining into it during the fall is the effective mound volume:

$$V' = V_a' - (V_r' - V_i') + (V_r' - V_f') = V_a' - (V_f' - V_i')$$

where V_i', V_r', and V_f' were determined by averaging moisture profile observations in three neutron access tubes in the pond area.

From V_i' (table 2) and the appropriate fillable void (V) (table 1), the disk radius (a) at pond No. 1 equalled 894 feet and at pond No. 2, 910 feet. These values were used along with the aquifer parameters from the pump test to evaluate equations. The observed and theoretical hydrograph data were plotted on figure 9. The agreement at pond No. 1 was quite good with the apparent deviation being explained in part by the fact that the wetted depth (D = 16 feet) used in the theoretical evaluation was low in comparison with the actual mound

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[8]This expression would include the storage in the perched water table with the vadose zone at pond No. 2.

height (H = 5.27 feet) during the initial period of fall.

At pond No. 2, the observed mound fell at a rate considerably slower than that predicted. When we solve equation 6 for a, using the observed data for the initial 15 days of fall, the mound appears to be reacting as if it had a radius of 1,440 feet rather than 910 feet. In part, the reason for this difference is the relatively large amount of storage present in the vadose zone be-

Table 2.--*Storage distribution in the mound and vadose zone beneath the ponds*

	Pond No. 1	Pond No. 2
	Acre-ft	*Acre-ft*
V_a' = total volume metered on the 2-acre pond	32.90	11.90
V_i' = volume in vadose zone at beginning of spreading	9.14	10.94
V_r' = volume of vadose zone at end of spreading	17.74	17.44
V_f' = volume in vadose zone at end of observed fall	15.00	14.44
V' = effective mound volume	27.04	8.40

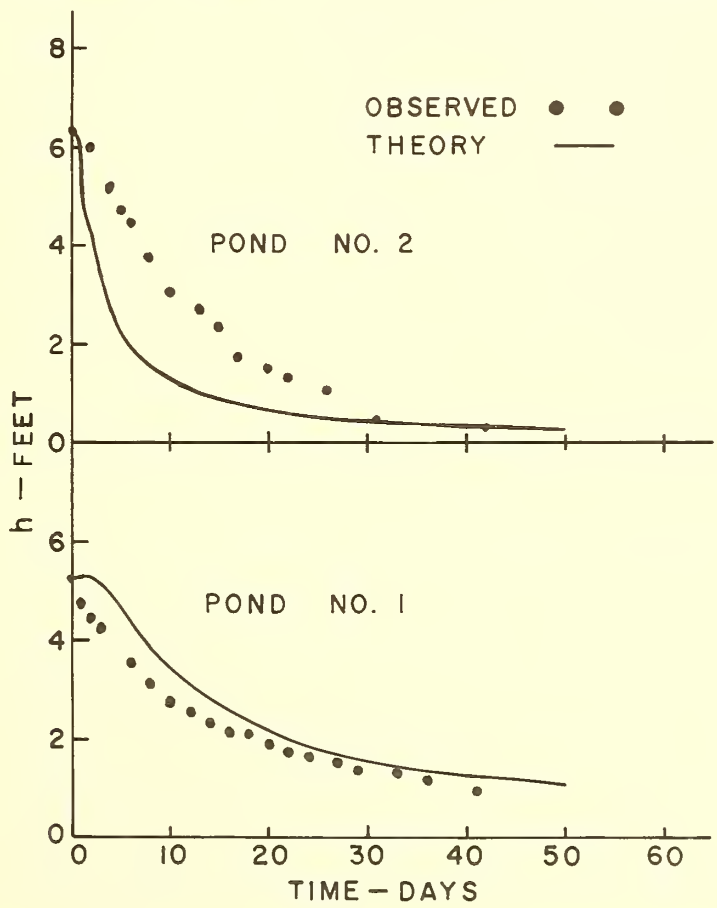

Figure 9.--Observed and theoretical falling hydrographs at the center of the two ponds.

neath this pond and the possible restrictions on its rate of release through the perching layer there. Taking the difference between V_r' and V_f' in table 2, we see that for pond No. 1 only 2.74 acre-feet of the 27.04 acre-feet was delivered to the mound after the fall began; however, 3.00 acre-feet out of the total 8.40 was delivered at pond No. 2. Note that for pond No. 2 the deviation disappears as time advances and vadose drainage decreases. Thus, if the mound is small, vadose drainage can greatly influence the falling hydrograph.

DISCUSSION

The major assumptions regarding ground water flow are listed in table 3 with comment as to what extent they may have influenced the comparison of theory to observation in our two field trials.

The Dupuit-Forschheimer (D-F) (*7*,*9*) assumptions as applied by Glover (*10*)[9] seemed to be quite acceptable. This may be due in part to our use of the well test method for determining K and V, as the Theis nonequilibrium method is also based on the D-F assumptions, this could bias K and V toward horizontal flow. Rigorously, the Theis method does not apply to the water table case here; however, it is the one most commonly used and can provide acceptable values when applied with the reservations stated by Ferris (*8*).

Table 3.--*Influence rating of assumptions apparent from field trials*

Assumption	Acceptable	Questionable	Unacceptable
Rising mound:			
D-F flow theory	X		
Well test for K and V	X		
Square area transformed to circle	X		
Stratigraphic definition of D			X
D constant with time		X	
Uniform i		X	
t_0 from wet front	X		
Horizontally uniform V		X	
Falling mound:			
No vadose drainage			X
Disk-shaped mound height (H) from center of pond; volume corrected for vadose storage	X		

In the static water table, the stratigraphic analysis and piezometric head loss used to define possible perching above the water table and the wetted depth (D) proved in error. The hydraulic response of individual layers in the profile cannot be evaluated unless monitored under flow conditions closely approaching those associated with recharge. Also, exclusion of the mound height from the evaluation of D had a recognizable influence on the comparison in the pond where D was small.

The time dependency of the initial i after t_0 determined from the wet front position led to some deviation between theory and observation during the initial

[9]Also see footnote 2.

period of rise in the hydrograph. However, if the mound volume is small relative to the drainable volume held in the vadose zone beneath the pond, continued drainage after spreading has ceased can greatly influence the falling hydrograph.

Although the assumption of a uniform value for V equal to that obtained by the well test gives reasonable theoretical estimates of the hydrograph directly beneath the pond, its use in the evaluation of water table elevations away from the plot boundaries leads to error. A separate estimate of V is required where the water table is moving up into drained soil or the equilibrium capillary fringe.

The assumption that the initial shape of the falling mound was that of a disk was not too restrictive. If these mounds are plotted to 1:1 scale, their relief appears slight (*12*).

In summary, narrowing the discrepancy between theory and field observation appears to depend more on improved field definition of flow and storage responses within the vadose zone and below the water table at individual recharge sites than on any further refinements in the flow theory and its mathematical treatment.

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APPENDIX

Table 1.--*Net rise in observation well versus time for pond No. 1, Westside Field Station at Five Points*

Well No.[2]	Elapsed days							
	-5.875	-3.875	-2.875	-2.017	-1.753	-0.976	0.000[1]	1.000
	Well rise (in feet) above average head prior to elapsed day (-5.875)							
1	0.06	0.11	0.08	0.12	0.20	0.15	0.13	0.23
2	.05	.10	.10	.18	.26	.24	.26	.43
2A	.07	.16	.17	.25	.34	.35	.39	.61
3	.06	.15	.18	.30	.38	.43	.58	.89
3A	.08	.18	.25	.38	.43	.55	.77	1.20
4	.08	.21	.27	.45	.39	.65	.88	1.31
5	.06	.21	.31	.54	.65	.82	1.13	1.55
6	.07	.29	.45	.70	.80	.98	1.29	1.64
6A	.08	.23	.39	.61	.68	.87	1.12	1.39
7	.04	.17	.26	.40	.48	.58	.75	.97
7A	.09	.16	.21	.30	.34	.43	.55	.73
8	.03	.10	.12	.19	.24	.29	.37	.52
9	.04	.10	.09	.13	.19	.18	.20	.31
10	.05	.21	.31	.63	.61	.74	.94	1.25
11	.06	.15	.19	.22	.40	.44	.55	.75
12	.04	.11	.09	.16	.22	.22	.27	.40
13	.03	.07	.05	.10	.16	.14	.16	.29
14	.14	.38	.48	.75	.86	1.04	1.29	1.64
15	.14	.31	.39	.59	.72	.77	.93	1.22
16	.13	.23	.23	.36	.46	.46	.50	.72
17	.11	.17	.15	.25	.30	.26	.27	.45
18	.15	.31	.35	.50	.61	.63	.75	1.09
19	.03	.09	.08	.13	.16	.19	.24	.34
20	.05	.18	.17	.24	.30	.34	.43	.58
21	.05	.21	.15	.21	.25	.27	.35	.52
	Elapsed days							
	1.208	2.139	3.125	4.125	5.146	6.146	7.146	9.028
1	0.32	0.36	0.43	0.56	0.66	0.75	0.89	1.07
2	.62	.66	.84	1.01	1.20	1.34	1.55	1.86
2A	.70	.89	1.15	1.38	1.62	1.82	2.08	2.41
3	1.00	1.29	1.67	2.05	2.37	2.65	2.95	3.37
3A	1.33	1.77	2.28	2.71	3.09	3.41	3.73	4.20
4	1.44	1.89	2.46	2.86	3.20	3.42	3.81	4.27
5	1.68	2.09	2.52	2.87	3.20	3.49	3.81	4.21
6	1.74	2.02	2.34	2.64	2.89	3.14	3.41	3.77

See footnotes at end of table.

Table 1.--*Net rise in observation well versus time for pond No. 1, Westside Field Station at Five Points*--*Continued*

Well No.[2]	Elapsed days 1.208	2.139	3.125	4.125	5.146	6.146	7.146	9.028
	Well rise (in feet) above average head prior to elapsed day (-5.875)							
6A	1.48	1.73	2.00	2.22	2.47	2.68	2.94	3.27
7	1.04	1.24	1.47	1.66	1.86	2.04	2.24	2.55
7A	.77	.91	1.09	1.26	1.44	1.60	1.77	2.04
8	.56	.68	.82	.97	1.12	1.24	1.40	1.66
9	.37	.45	.57	.68	.75	.84	.95	1.14
10	1.35	1.64	1.91	2.20	2.44	2.65	2.92	3.30
11	.85	1.05	1.27	1.46	1.64	1.80	2.03	2.37
12	.45	.57	.70	.80	.91	1.02	1.16	1.39
13	.33	.42	.53	.78	.73	.78	.90	1.08
14	1.78	2.14	2.52	2.83	3.13	3.38	3.67	3.98
15	1.36	1.61	1.92	2.14	2.37	2.53	2.80	3.05
16	.85	.99	1.21	1.41	1.55	1.66	1.88	2.10
17	.55	.65	.81	.97	1.08	1.17	1.31	1.51
18	1.18	1.36	1.62	1.85	2.06	2.21	2.43	2.70
19	.37	.47	.64	.83	1.01	1.19	1.39	1.72
20	.63	.77	.93	1.08	1.19	1.32	1.48	1.73
21	.57	.72	.92	1.12	1.29	1.48	1.68	1.98

Well No.	Elapsed days 11.021	13.066	15.062	19.062	22.062	25.062	28.062[3]	30.916
1	1.29	1.57	1.83	2.12	2.27	2.39	2.45	2.54
2	2.11	2.51	2.78	3.06	3.24	3.32	3.40	3.46
2A	2.74	3.61	3.46	3.78	4.00	4.05	4.10	4.15
3	3.69	4.15	4.56	4.82	5.03	4.95	4.95	5.00
3A	4.51	5.04	5.47	5.62	5.82	5.65	5.59	5.62
4	4.57	5.11	5.51	5.65	5.81	5.63	5.59	5.63
5	4.50	5.03	5.37	5.48	5.65	5.44	5.43	5.47
6	3.99	4.43	4.76	4.87	5.03	4.92	4.90	4.95
6A	3.47	3.84	4.14	4.28	4.49	4.42	4.44	4.50
7	2.77	3.09	3.37	3.61	3.79	3.79	3.85	3.89
7A	2.28	2.56	2.82	3.06	3.27	3.34	3.38	3.46
8	1.85	2.10	2.34	2.61	2.81	2.89	2.94	3.01
9	1.32	1.53	1.71	1.96	2.13	2.29	2.34	2.39
10	3.62	3.98	4.34	4.58	4.73	4.65	4.67	4.73
11	2.65	2.97	3.26	3.58	3.78	3.80	3.85	3.90
12	1.64	1.87	2.12	2.46	2.65	2.76	2.82	2.87
13	1.29	1.52	1.73	2.00	2.19	2.33	2.42	2.49
14	4.29	4.83	5.12	5.25	5.42	5.25	5.20	5.25

See footnotes at end of table.

Table 1.--*Net rise in observation well versus time for pond No. 1, Westside Field Station at Five Points--Continued*

Well No.[2]	Elapsed days							
	11.021	13.066	15.062	19.062	22.062	25.062	28.062[3]	30.916
	Well rise (in feet) above average head prior to elapsed day (-5.875)							
15	3.34	3.85	4.08	4.30	4.46	4.41	4.39	4.44
16	2.32	2.71	2.91	3.17	3.30	3.39	3.42	3.48
17	1.66	2.01	2.19	2.41	2.55	2.67	2.72	2.78
18	2.99	3.46	3.72	3.98	4.17	4.17	4.16	4.22
19	1.96	2.40	2.70	3.07	3.30	3.40	3.42	3.49
20	1.99	2.22	2.49	2.80	2.99	3.07	3.13	3.21
21	2.23	2.54	2.83	3.13	3.35	3.39	3.46	3.53
	Elapsed days							
	0.00[4]	0.993	1.993	2.993	3.993	5.993	7.993	9.993
1	2.57	2.53	2.46	2.42	2.40	2.33	2.14	1.91
2	3.47	3.36	3.25	3.12	3.01	2.85	2.58	2.30
2A	4.21	4.04	3.76	3.58	3.43	3.17	2.85	2.54
3	4.91	4.57	4.31	4.09	3.89	3.52	3.15	2.80
3A	5.48	5.04	4.74	4.53	4.25	3.78	3.37	2.96
4	5.45	4.98	4.67	4.66	4.16	3.69	3.28	2.89
5	5.27	4.78	4.45	4.21	3.93	3.56	3.14	2.78
6	4.82	4.39	4.09	3.89	3.65	3.29	2.93	2.61
6A	4.40	4.06	3.80	3.61	3.40	3.10	2.79	2.46
7	3.85	3.59	3.40	3.24	3.08	2.82	2.57	2.28
7A	3.46	3.29	2.13	2.99	2.90	2.70	2.46	2.20
8	3.04	2.91	2.78	2.70	2.61	2.45	2.26	2.01
9	2.44	2.39	2.30	2.24	2.18	2.08	1.93	1.74
10	4.65	4.29	2.04	3.81	3.62	3.24	2.89	2.57
11	3.89	3.66	3.49	3.32	3.16	2.87	2.59	2.31
12	2.92	2.81	2.75	2.63	2.56	2.38	2.20	1.95
13	2.53	2.47	2.41	2.31	2.26	2.14	1.97	1.76
14	5.09	4.61	4.32	4.06	3.82	3.46	3.06	2.71
15	4.36	4.03	3.76	3.54	3.35	3.05	2.75	2.43
16	3.46	3.26	3.08	2.94	2.83	2.64	2.37	2.09
17	2.81	2.67	2.54	2.46	2.40	2.28	2.05	1.81
18	4.19	3.90	3.67	3.49	3.29	3.05	2.70	2.37
19	3.51	3.40	3.27	3.14	3.04	2.81	2.56	2.32
20	3.21	3.08	2.94	2.81	2.70	2.50	2.29	2.07
21	3.54	3.34	3.18	3.07	2.95	2.65	2.52	2.27

See footnotes at end of table.

Table 1.--*Net rise in observation well versus time for pond No. 1, Westside Field Station at Five Points--Continued*

Well No.[2]	Elapsed days							
	11.993	13.993	15.993	17.993	19.993	21.993	23.993	26.993
	Well rise (in feet) above average head prior to elapsed day (-5.875)							
1	1.90	1.80	1.62	1.62	1.51	1.49	1.41	1.29
2	2.21	2.07	1.86	1.86	1.70	1.64	1.52	1.39
2A	2.41	2.25	2.01	1.99	1.81	1.74	1.60	1.47
3	2.61	2.41	2.17	2.08	1.93	1.83	1.70	1.58
3A	2.73	2.50	2.29	2.13	1.97	1.86	1.73	1.63
4	2.65	2.44	2.21	2.09	1.93	1.82	1.68	1.59
5	2.56	2.35	2.14	2.02	1.85	1.79	1.66	1.53
6	2.41	2.22	2.04	1.93	1.81	1.73	1.60	1.49
6A	2.29	2.15	1.97	1.88	1.74	1.67	1.54	1.44
7	2.14	1.99	1.83	1.76	1.65	1.57	1.46	1.37
7A	2.07	1.94	1.82	1.75	1.63	1.56	1.45	1.36
8	1.90	1.79	1.67	1.61	1.50	1.44	1.32	1.25
9	1.70	1.61	1.47	1.44	1.35	1.31	1.21	1.14
10	2.39	2.30	2.00	1.90	1.76	1.67	1.56	1.45
11	2.20	2.02	1.84	1.77	1.64	1.55	1.44	1.37
12	1.90	1.76	1.62	1.60	1.49	1.43	1.31	1.23
13	1.75	1.64	1.48	1.46	1.37	1.32	1.22	1.14
14	2.57	2.39	2.14	2.10	1.92	1.84	1.68	1.58
15	2.39	2.24	1.98	2.02	1.83	1.77	1.61	1.47
16	2.10	1.99	1.71	1.80	1.62	1.59	1.49	1.38
17	1.87	1.79	1.52	1.65	1.48	1.48	1.36	1.26
18	2.34	2.20	1.90	1.95	1.75	1.72	1.57	1.45
19	2.16	1.99	1.83	1.75	1.62	1.53	1.44	1.35
20	1.96	1.83	1.68	1.62	1.51	1.44	1.33	1.25
21	2.14	2.01	1.85	1.77	1.65	1.58	1.47	1.37

Well No.[2]	Elapsed days							
	28.993	32.993	35.993	40.993	45.993	48.993	55.993	63.993
1	1.16	1.10	1.06	0.84	0.74	0.66	0.53	0.49
2	1.24	1.17	1.10	.91	.79	.70	.56	.50
2A	1.32	1.26	1.18	1.03	.84	.74	.58	.52
3	1.41	1.30	1.21	1.02	.89	.79	.61	.55
3A	1.48	1.34	1.25	1.05	.92	.83	.61	.59
4	1.44	1.31	1.22	1.00	.88	.79	.57	.56
5	1.40	1.27	1.19	.98	.84	.78	.59	---
6	1.36	1.24	1.16	.93	.86	.77	.58	.52
6A	1.32	1.21	1.14	.95	.82	.74	.54	.49
7	1.24	1.14	1.06	.88	.75	.67	.53	.45

See footnotes at end of table.

Table 1.--*Net rise in observation well versus time for pond No. 1, Westside Field Station at Five Points--Continued*

Well No.[2]	Elapsed days							
	28.993	32.993	35.993	40.993	45.993	48.993	55.993	63.993
	Well rise (in feet) above average head prior to elapsed day (-5.875)							
7A	1.24	1.14	1.06	0.90	0.79	0.70	0.50	0.47
8	1.15	1.05	.98	.83	.70	.66	.48	.40
9	1.04	.94	.89	.74	.63	.55	.40	.32
10	1.33	1.20	1.12	.93	.80	.71	.55	.49
11	1.24	1.13	1.06	.87	.74	.66	.48	.44
12	1.10	1.02	.95	.77	.69	.59	.44	.36
13	1.02	.95	.87	.72	.62	.53	.40	.30
14	1.41	1.28	1.22	.99	.86	.77	.52	.55
15	1.29	1.22	1.16	.94	.82	.91	.50	.52
16	1.18	1.16	1.11	.87	.75	.67	.47	.50
17	1.11	1.09	1.06	.82	.73	.65	.47	.48
18	1.28	1.23	1.18	.93	.82	.73	.49	.46
19	1.23	1.11	1.09	.86	.75	.70	.51	.44
20	1.16	1.06	.78	.66	.69	.62	.45	.36
21	1.27	1.16	1.09	.90	.78	.70	.53	.44

[1]Assumed as $t = 0$ for rising hydrographs.

[2]For well spacing see figure 1.

[3]Casing failure in deep well supplying pond caused a cutback in input rate (i).

[4]Day that all surface water was drained from plot, therefore assumed as $t' = 0$ for falling mound.

Table 2.--*Net rise in observation well versus time for pond No. 2, near Cantua Creek*

Well No.[2]	Elapsed days: -0.938	-0.726	-0.420	-0.181	0.00[1]	0.115	0.278	0.378
	Well rise (in feet) above average head prior to elapsed day (-0.938)							
1	-0.04	0.00	-0.04	-0.05	-0.04	0.00	0.04	0.04
2	- .06	- .03	- .05	- .05	- .02	.04	.08	.09
2A								
3	.07	.16	.25	.33	.41	.54	.68	.76
3A								
4	- .02	.03	.06	.15	.21	.23	.31	.36
5	.14	.25	.44	.61	.80	.95	1.15	1.29
5A								
6	.10	.20	.30	.44	.59	.74	.94	1.07
7	.10	.19	.29	.39	.59	.72	.92	1.02
7A								
8	.03	.15	.30	.42	.60	.75	1.00	1.13
9	.11	.22	.31	.52	.75	.91	1.13	1.23
P_0								
10	- .03	.07	.11	.29	.48	.65	.87	.97
11	.02	.11	.20	.30	.48	.66	.83	.92
12	.00	.08	.21	.23	.38	.51	.71	.79
12A								
13	- .03	.06	.10	.16	.25	.39	.55	.64
14	- .01	.01	.09	.16	.28	.41	.56	.61
14A								
15	.01	.04	.08	.13	.25	.34	.49	.55
15A								
16	- .05	.02	.04	.08	.18	.30	.42	.47
16A								
17	.07	.12	.15	.15	.23	.33	.43	.46
17A								
18	- .03	- .02	- .03	- .04	- .02	- .04	---	.01
19	- .07	- .04	- .07	- .10	- .10	- .04	- .04	- .03
20	.09	.16	.21	.31	.47	.63	.83	.97
21	.00	.08	.15	.26	.39	.53	.66	.75
22	- .04	.00	.01	.03	.06	.17	.23	.25
22A								
23	.00	.04	.00	- .02	.05	.07	.09	.09
24	.16	.24	.40	.54	.78	.89	1.09	1.21
25	.12	.18	.32	.36	.49	.63	.78	.84
26	.01	.05	.10	.12	.21	.30	.39	.44
27	- .01	.00	.01	.03	.05	.11	.16	.17

See footnotes at end of table.

Table 2.--*Net rise in observation well versus time for pond No. 2, near Cantua Creek--Continued*

Well No.[2]	Elapsed days							
	0.573	0.774	0.920	1.052	1.277	1.552	1.815	2.135
	Well rise (in feet) above average head prior to elapsed day (-0.938)							
1	0.05	0.10	0.12	0.17	0.28	0.31	0.34	0.51
2	.13	.20	.24	.33	.43	.52	.63	.78
2A								
3	.95	1.19	1.37	1.57	1.85	2.12	2.45	2.87
3A								
4	.48	.68	.87	1.11	1.86	2.36	2.73	3.18
5	1.61	1.95	2.15	2.40	2.77	3.11	3.53	4.04
5A								
6	1.39	1.76	2.00	2.28	2.72	3.11	3.57	4.06
7	1.32	1.72	1.99	2.32	2.77	3.16	3.59	4.08
7A								
8	1.45	1.80	2.09	2.37	2.79	3.19	3.61	4.09
9	1.52	1.85	2.05	2.29	2.68	3.05	3.41	3.90
P_1								
10	1.23	1.54	1.71	1.93	2.31	2.65	2.99	3.44
11	1.16	1.48	1.65	1.88	2.27	2.57	2.92	3.38
12	1.05	1.33	1.49	1.71	2.08	2.41	2.73	3.17
12A								
13	.85	1.14	1.30	1.51	1.89	2.30	2.70	3.27
14	.84	1.07	1.22	1.42	1.74	2.01	2.31	2.74
14A								
15	.73	.95	1.09	1.28	1.58	1.83	2.12	2.52
15A								
16	.64	.86	1.02	1.19	1.47	1.72	2.01	2.41
16A								
17	.58	.75	.86	1.00	1.20	1.45	1.63	2.08
17A								
18	.15	.24	.31	.38	.56	.65	.77	.96
19	- .03	.01	.04	.06	.18	.25	.30	.41
20	---	1.57	1.77	2.00	2.34	2.65	2.97	3.38
21	---	1.20	1.32	1.48	1.74	1.93	2.14	2.42
22	---	.47	.54	.63	.82	.94	1.08	1.29
22A								
23	---	.20	.27	.33	.48	.23	.63	.81
24	---	1.80	1.99	2.20	2.59	2.94	3.24	3.70
25	---	1.28	1.46	1.63	1.95	2.19	2.44	2.80
26	---	.71	.83	.96	1.16	1.39	1.53	1.83
27	---	.31	.39	.43	.59	.69	.79	.97

See footnotes at end of table.

Table 2.--*Net rise in observation well versus time for pond No. 2, near Cantua Creek--Continued*

Well No.[2]	Elapsed days: 2.472	2.801	3.124	3.926	4.905	5.926	6.968	7.968
	Well rise (in feet) above average head prior to elapsed day (-0.938)							
1	0.61	0.69	0.80	1.01	1.25	1.49	1.58	1.81
2	.93	1.05	1.21	1.54	1.90	2.22	2.40	2.66
2A			[3]2.45	2.93	3.43	3.83	3.99	4.25
3	3.25	---	3.81	4.57	5.17	5.56	5.68	5.82
3A						[3]6.04	6.22	6.34
4	3.62	4.02	4.35	5.11	5.77	6.26	6.49	6.62
5	4.43	4.84	5.25	6.05	6.67	7.04	7.07	7.19
5A						[3]7.83	7.90	7.96
6	4.45	4.79	5.15	5.87	6.50	6.86	6.95	7.04
7	4.46	4.80	5.14	5.84	6.44	6.81	6.81	6.96
7A						[3]9.10	9.13	9.22
8	4.46	4.79	5.15	5.80	6.35	6.67	6.84	6.83
9	4.27	4.58	4.93	5.57	6.07	6.39	6.32	6.51
P_1			[4]4.03	4.72	6.17	6.47	6.48	6.58
10	3.78	4.10	4.44	5.03	5.49	5.74	5.69	5.89
11	3.73	4.02	---	---	---	---	---	---
12	3.51	3.80	4.15	4.70	5.17	5.49	5.44	5.67
12A						[3]8.86	8.82	9.00
13	3.74	4.10	4.46	5.12	5.63	5.99	5.96	6.15
14	3.08	3.36	3.72	4.30	4.86	5.18	5.15	5.41
14A					[3]7.04	7.81	8.12	8.39
15	2.84	3.13	3.48	4.05	4.55	4.92	4.97	5.19
15A						[3]6.38	6.46	6.69
16	2.74	3.02	3.32	3.86	4.34	4.69	4.73	4.98
16A			[3]3.32	3.74	4.20	4.57	4.58	4.83
17	2.23	2.48	2.76	3.21	3.63	3.98	4.03	4.28
17A						[3]3.83	3.97	4.25
18	1.10	1.24	1.40	1.70	2.00	2.31	2.33	2.56
19	.52	.60	.70	.93	1.18	1.37	1.38	1.57
20	3.70	---	4.30	4.87	5.31	5.58	5.53	5.70
21	2.66	2.85	3.12	3.56	3.95	4.22	4.30	4.37
22	1.46	1.59	1.78	2.11	2.46	2.74	2.74	2.96
22A			[3]1.88	2.20	2.52	2.79	2.78	3.00
23	.93	1.00	.95	1.38	1.66	1.92	1.97	2.19
24	3.99	4.26	4.58	5.07	5.49	5.77	5.77	6.01
25	3.04	3.22	3.50	3.93	4.31	4.57	4.59	4.84
26	2.06	3.19	2.44	2.79	3.16	3.47	3.51	3.79
27	1.11	1.20	1.38	1.62	1.85	2.09	2.09	2.31

See footnotes at end of table.

Table 2.--*Net rise in observation well versus time for pond No. 2, near Cantua Creek--Continued*

Well No.[2]	Elapsed days							
	8.905	0.00[5]	2.094	4.021	5.010	6.052	8.052	11.198
	Well rise (in feet) above average head prior to elapsed day (-0.938)							
1	1.94	2.23	2.29	2.26	2.21	2.16	1.98	1.71
2	2.74	3.14	3.23	3.16	3.02	2.91	2.65	2.26
2A	4.37	4.62	4.59	4.27	4.03	3.80	3.36	2.75
3	5.95	6.14	5.97	5.37	5.01	4.68	4.04	3.23
3A	6.41	6.55	6.41	5.79	5.44	5.03	4.32	---
4	6.71	6.83	6.76	6.06	5.65	5.19	4.54	3.58
5	7.18	7.32	6.95	6.05	5.57	5.16	4.43	3.48
5A	7.96	8.02	7.61	6.54	6.01	5.55	4.77	3.82
6	7.06	7.16	6.83	5.95	5.50	5.08	4.41	3.45
7	6.97	7.08	6.74	5.85	5.39	4.98	4.33	3.40
7A	9.19	9.17	8.71	7.38	6.80	6.29	5.51	4.19
8	6.86	7.01	6.59	5.70	5.21	4.83	4.20	3.28
9	6.54	6.69	6.27	5.44	5.00	4.61	4.01	3.19
P_1	6.63	6.74	6.61	5.93	5.58	5.11	4.45	3.57
10	5.91	6.07	5.68	4.94	4.51	4.20	3.58	2.87
11	---	---	---	---	---	---	---	---
12	5.70	5.87	5.53	4.83	4.44	4.10	3.50	2.82
12A	9.02	9.15	8.65	7.55	6.99	6.41	4.63	3.53
13	6.18	6.29	5.93	5.14	4.72	4.41	3.77	2.95
14	5.46	5.63	5.34	4.70	4.30	4.00	3.47	2.75
14A	8.52	8.69	8.36	7.28	6.69	6.17	5.33	4.77
15	5.34	5.40	5.15	4.54	4.19	3.88	3.37	2.67
15A	6.87	7.14	7.07	6.43	5.92	5.37	4.70	3.77
16	5.05	5.25	5.02	4.46	4.12	3.82	3.31	2.63
16A	4.89	5.08	4.93	4.35	4.01	3.81	3.25	2.61
17	4.38	4.58	4.44	4.03	3.74	3.51	3.08	2.50
17A	4.41	4.73	4.73	4.37	4.09	3.84	3.36	2.73
18	2.77	2.87	2.81	2.69	2.52	2.40	2.13	1.79
19	1.68	1.87	1.84	1.83	1.75	1.68	1.51	1.28
20	5.70	5.79	5.48	4.80	4.42	4.15	3.55	2.82
21	4.39	4.51	4.29	3.85	3.56	3.33	2.86	2.29
22	2.93	3.19	3.10	2.94	2.76	2.62	2.31	1.90
22A	3.08	3.23	3.14	2.96	2.80	2.68	2.36	1.97
23	2.28	2.42	2.38	2.32	2.20	2.13	1.91	1.60
24	6.03	6.27	5.81	5.02	4.60	4.27	3.72	2.97
25	4.91	5.11	4.84	4.26	3.94	3.71	3.22	2.62
26	3.88	4.11	3.97	3.62	3.38	3.20	2.78	2.26
27	2.40	2.60	2.55	2.42	2.28	2.20	1.96	1.65

See footnotes at end of table.

Table 2.--*Net rise in observation well versus time for pond No. 2, near Cantua Creek--Continued*

Well No.[2]	Elapsed days							
	13.229	14.989	17.989	19.989	21.989	25.989	30.989	41.989
	Well rise (in feet) above average head prior to elapsed day (-0.938)							
1	1.67	1.47	1.25	1.15	1.06	0.86	0.46	0.28
2	2.07	1.83	1.52	1.38	1.24	.97	.56	.30
2A	2.45	2.14	1.74	1.57	1.39	1.11	.66	.39
3	2.83	2.45	1.95	1.72	1.53	1.21	.74	.42
3A	---	---	---	---	---	---	---	---
4	3.10	2.73	2.17	1.84	1.61	1.25	.81	.36
5	3.00	2.57	2.04	1.75	1.54	1.19	.70	.38
5A	3.82	---	---	---	---	---	---	---
6	2.93	2.52	1.97	1.74	1.54	1.19	.69	.40
7	2.94	2.49	1.96	1.72	1.51	1.18	.58	.40
7A	3.66	---	---	---	---	---	---	---
8	2.82	2.38	1.78	1.61	1.40	1.08	.56	.29
9	2.74	2.57	1.80	1.58	1.37	1.07	.52	.30
P_1	3.08	2.73	2.12	---	---	---	---	---
10	2.51	2.11	1.63	1.41	1.24	.94	.40	.22
11	---	---	---	---	---	---	---	---
12	2.47	2.07	1.60	1.41	1.22	.93	.41	.22
12A	2.95	2.41	2.00	---	---	---	---	---
13	2.58	2.17	1.66	1.45	1.25	.94	.41	.22
14	2.39	2.00	1.48	1.36	1.18	.90	.39	.20
14A	---	---	---	---	---	---	---	---
15	2.34	1.95	1.51	1.33	1.14	.87	.37	.19
15A	3.09	---	---	---	---	---	---	---
16	2.32	1.94	1.48	1.31	1.13	.86	.34	.16
16A	2.30	1.92	1.52	1.33	1.17	.89	.40	.20
17	2.20	1.86	1.48	1.38	1.16	.89	.41	.24
17A	2.43	2.05	1.78	---	---	---	---	---
18	1.61	1.34	1.04	.81	.61	.48	.09	.04
19	1.19	.99	.78	.69	.58	.37	.00	.33
20	2.48	2.10	1.63	1.44	1.26	1.00	.48	.27
21	2.01	1.66	1.27	1.13	.97	.73	.28	.08
22	1.71	1.44	1.14	1.01	.85	.65	.18	.02
22A	1.79	1.52	1.15	1.08	.94	.75	---	---
23	1.45	1.24	1.03	.93	.84	.65	.25	.09
24	2.60	2.21	1.74	1.53	1.35	1.05	.57	.37
25	2.30	1.98	1.55	1.38	1.22	.99	.49	.37
26	2.01	1.70	1.40	1.26	1.11	.90	.49	---
27	1.53	1.31	---	---	---	---	---	---

[1]Assumed as $t = 0$ for rising hydrographs.
[2]For well spacing, see figure 2.
[3]First observation; shallower well added. See text, p. 4.
[4]First observation; neutron probe tube. See text, p. 4.
[5]Assumed as $t' = 0$ for falling mound.

Table 3.--*Wells averaged for rise and fall comparisons*

Center	Distance from center (X, Y = 0) in feet				$Y = X$
0	74.0	148.0	222.0	296.0	74.0
Well numbers for pond No. 1, Westside Field Station at Five Points					
5	4	3	2	1	18
	6	7	8	9	19
	10	11	12	13	20
	14	15	16	17	21
Well numbers for pond No. 2, near Cantua Creek					
9	6	3	2	1	
10	13	16	18	19	
	20	21	22	23	
	24	25	26	27	

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